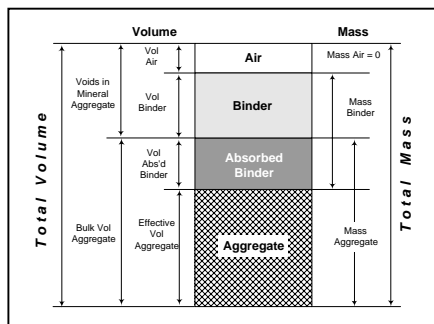


BULK SPECIFIC GRAVITY OF COMPACTED HOT MIX ASPHALT MIXTURES USING SATURATED SURFACE-DRY SPECIMENS FOP FOR AASHTO T 166

BULK SPECIFIC GRAVITY OF COMPACTED BITUMINOUS MIXTURES USING PARAFFIN-COATED SPECIMENS FOP FOR AASHTO T 275



HMA core



HMA phase diagram

Significance

Compacted hot mix asphalt (HMA) include voids that may contain gas, such as air, or liquid, such as water. The voids may be permeable, that is, they connect to the surface and can fill with water. They may also be impermeable and, thus, filled only with air.

Because voids exist and contain air or water, the overall, or bulk, density of the compacted mix is less than the density of a theoretical mix of aggregate and binder having no voids. Thus, bulk density, and associated bulk specific gravity are indications of void and air content – both of which impact various properties of bituminous roadways.

Bulk specific gravity is the ratio of the mass of a given volume of dry, compacted mix at 25°C (77°F) in air to the mass of an equal volume of water at the same temperature. The weight of the sample in water is subtracted from the mass of a saturated surface-dry (SSD) sample in air in order to determine the mass of the water displaced by the specimen. The measurement of void volume, which includes permeable internal and surface pores occupied by water, is useful for mix quality control because it takes into consideration the volume of voids permeable to water within the specimen.

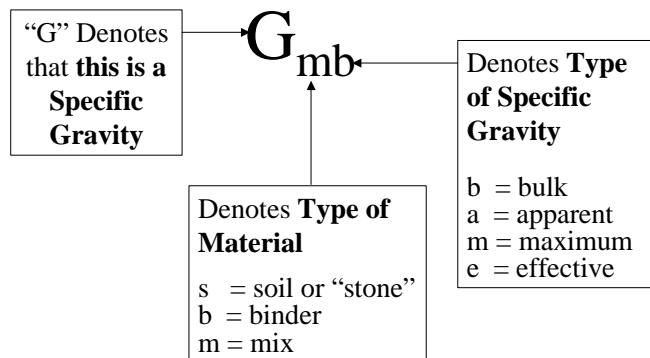
Scope

This procedure covers the determination of bulk specific gravity (G_{mb}) of compacted HMA using three methods – A, B, and C – in accordance with AASHTO T 166. These three methods are for use on specimens not having open or inter-connecting voids and/or not absorbing more than 2.0 percent water by volume. A fourth and fifth method – D & E – in accordance with AASHTO T 275 and covering specimens having open or interconnecting

voids and / or absorbing more than 2.0 percent water by volume is also included.

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Definition: (Specific Gravity Symbols)



Overview

- Method A Suspension
- Method B Volumeter
- Method C Rapid test for A or B
- Method D Suspension for coated specimen
- Method E Volumeter for coated specimen

Test Specimens

Test specimens may be either laboratory-molded or from HMA pavement. For specimens it is recommended that the diameter be equal to four times the maximum size of the aggregate and the thickness be at least one and one half times the maximum size of the aggregate.

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Apparatus – Method A (Suspension)



Suspension apparatus

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- Balance or scale: 5 kg capacity, readable to 0.1 g, fitted with a suitable suspension apparatus and holder to permit weighing the specimen while suspended in water and conforming to AASHTO M 231.
- Suspension apparatus: Wire of the smallest practical size and constructed to permit the container to be fully immersed.
- Water bath: For immersing the specimen in water while suspended under the balance or scale, and equipped with an overflow outlet for maintaining a constant water level.
- Towel: Damp towel used for surface drying specimens.
- Oven: Capable of maintaining a temperature of $110 \pm 5^{\circ}\text{C}$ ($230 \pm 9^{\circ}\text{F}$) for drying the specimens to a constant mass.

Note 1: AASHTO T 166 defines constant mass as the mass that further drying at $52 \pm 3^{\circ}\text{C}$ ($125 \pm 5^{\circ}\text{F}$) does not alter the mass by more than 0.05 percent. It also states that samples shall initially be dried overnight and that mass determinations shall be made at 2-hour drying intervals. AASHTO T 166 also states that recently molded laboratory samples that have not been exposed to moisture do not need drying.

- Pan: Pan or other suitable container of known mass, large enough to hold a sample for drying in oven.
- Thermometer: Having a range of 19 to 27°C (66 to 80°F), graduated in 0.1°C (0.2°F) subdivisions.

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Procedure - Method A (Suspension)

1. Dry the specimen to constant mass, if required. See note #1.

Note 2: To expedite the procedure steps 1 and 2 may be performed last. To further expedite the process see Method C.

2. Cool the specimen in air at $25 \pm 5^{\circ}\text{C}$ ($77 \pm 9^{\circ}\text{F}$), and determine and record the dry mass to the nearest 0.1 g. Designate this mass as “A”.



Immersing specimen

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3. Fill the water bath to overflow level with water at $25 \pm 1^{\circ}\text{C}$ ($77 \pm 1.8^{\circ}\text{F}$).
4. Immerse the specimen for 4 ± 1 minutes.
5. Determine and record the submerged weight to the nearest 0.1 g. Designate this submerged weight as "C".
6. Remove the sample from the water and quickly surface dry with a damp towel.
7. Determine and record the mass of the SSD specimen to nearest 0.1 g. Designate this mass as "B". Any water that seeps from the specimen during the mass determination is considered part of the saturated specimen.

Calculations - Method A (Suspension)

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$$G_{mb} = \frac{A}{B - C}$$

where:

- G_{mb} = Bulk Specific Gravity
- A = Mass of dry specimen in air, g
- B = Mass of SSD specimen in air, g
- C = Weight of specimen in water, g

$$\text{Percent Water Absorbed (by volume)} = \frac{B - A}{B - C} \times 100$$

Apparatus – Method B (Volumeter)

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- Balance or scale: 5 kg capacity, readable to 0.1 g and conforming to AASHTO M 231.
- Water bath: thermostatically controlled to $25 \pm 0.5^{\circ}\text{C}$ ($77 \pm 0.9^{\circ}\text{F}$)
- Thermometer: Range of 19 to 27°C (66 to 80°F), and graduated in 0.1°C (0.2°F) subdivisions
- Volumeter: Calibrated to 1200 mL or appropriate capacity for test sample and having a tapered lid with a capillary bore



Drying surface

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- Oven: Capable of maintaining a temperature of $110 \pm 5^{\circ}\text{C}$ ($230 \pm 9^{\circ}\text{F}$) for drying the specimens to a constant mass.
- Pan: Pan or other suitable container of known mass, large enough to hold a sample for drying in oven.
- Towel: Damp towel used for surface drying specimens.

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Procedure - Method B (Volumeter)

1. Dry the specimen to constant mass if required. See note 1.

Note 2: To expedite the procedure, steps 1 and 2 may be performed last. To further expedite the process see Method C.

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2. Cool the specimen in air at $25 \pm 5^{\circ}\text{C}$ ($77 \pm 9^{\circ}\text{F}$), and determine and record the dry mass to the nearest 0.1 g. Designate this mass as "A".
3. Immerse the specimen in the temperature controlled water bath for at least 10 minutes.
4. Fill the volumeter with distilled water at $25 \pm 1^{\circ}\text{C}$ ($77 \pm 1.8^{\circ}\text{F}$) making sure some water escapes through the capillary bore of the tapered lid. Wipe the volumeter dry. Determine the mass of the volumeter to the nearest 0.1 g. Designate this mass as "D".

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5. Remove the specimen from the water bath and quickly surface dry with a damp towel.

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6. Determine and record the mass of the SSD specimen to nearest 0.1 g. Designate this mass as "B". Any water that seeps from the specimen during the mass determination is considered part of the saturated specimen.

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7. Place the specimen in the volumeter and let stand 60 seconds.
8. Bring the temperature of the water to $25 \pm 1^{\circ}\text{C}$ ($77 \pm 1.8^{\circ}\text{F}$), and cover the volumeter making sure some water escapes through the capillary bore of the tapered lid.
9. Wipe the volumeter dry.

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10. Determine and record the mass of the volumeter and specimen to the nearest 0.1 g. Designate this mass as “E”.

Note 3: Method B is not acceptable for use with specimens that have more than 6 % air voids.

Calculations - Method B (Volumeter)

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$$G_{mb} = \frac{A}{B + D - E}$$

where:

G_{mb} = Bulk Specific Gravity

A = Mass of dry specimen in air, g

B = Mass of SSD specimen in air, g

D = Mass of volumeter filled with water at $25 \pm 1^\circ\text{C}$ ($77 \pm 1.8^\circ\text{F}$), g

E = Mass of volumeter filled with specimen and water, g

$$\% \text{ Water Absorbed (by volume)} = \frac{B - A}{B + D - E} \times 100$$

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Apparatus - Method C (Rapid Test for Method A or B)

See Methods A or B.

Note 4: This procedure can be used for specimens not required to be saved and that contain substantial amounts of moisture. Cores can be tested the same day as obtained by this method.

Procedure – Method C (Rapid Test for Method A or B)

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1. Determine which method to perform, A or B. Proceed with Method A or B, except that the dry mass, A, is determined last. In method A and B, start on step 3, complete that procedure then continue as follows to determine mass “A”.
2. Place the specimen on a large, flat bottom pan of known mass.
3. Heat at a minimum of 105°C (221°F), until the specimen can be easily separated to the point

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where the fine aggregate particles are not larger than 6.4 mm (1/4 in.). In no case should the Job Mix Formula mixing temperature be exceeded.

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4. Dry to constant mass. Constant mass is defined as the mass at which further drying at the temperature in step 3 does not change by more than 0.05% after an additional 2 hour drying time.
5. Cool to room temperature at $25 \pm 5^{\circ}\text{C}$ ($77 \pm 9^{\circ}\text{F}$).
6. Determine and record the mass of the pan and specimen to the nearest 0.1 g.
7. Determine and record the mass of the dry specimen to the nearest 0.1 g by subtracting the mass of the pan from the mass determined in Step 6. Designate this mass as "A".

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Calculations – Method C (Rapid Test for Method A or B)

Complete the calculations as outlined in Methods A or B, as appropriate.

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Materials – Method D Suspension (Coated Specimens/AASHTO T 275)

- Paraffin or parafilm: Used to coat test specimens.

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Apparatus – Method D Suspension (Coated Specimens/AASHTO T 275)

- Balance or scale: 5 kg capacity, readable to 0.1 g, fitted with a suitable suspension apparatus and holder to permit weighing the specimen while suspended in water and conforming to AASHTO M 231.
- Suspension apparatus: Wire of the smallest practical size and constructed to permit the container to be fully immersed.
- Water bath: For immersing the specimen in water while suspended under the balance or scale, and equipped with an overflow outlet for maintaining a constant water level.

- Oven: Capable of maintaining a temperature of $110 \pm 5^{\circ}\text{C}$ ($230 \pm 9^{\circ}\text{F}$) for drying the specimens to a constant mass. See note 1.
- Pan: Pan or other suitable container of known mass, large enough to hold a sample for drying in oven.

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Procedure - Method D Suspension (Coated Specimens/AASHTO T 275)

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1. Dry the specimen to constant mass, if required. See note 1.
2. Cool the specimen in air at $25 \pm 5^{\circ}\text{C}$ ($77 \pm 9^{\circ}\text{F}$), and determine and record the dry mass to the nearest 0.1 g. Designate this mass as “A”.
3. Coat specimen on all surfaces with melted paraffin, or parafilm coating, sufficiently thick to seal all voids.
4. Allow coating to cool in air at $25 \pm 5^{\circ}\text{C}$ ($77 \pm 9^{\circ}\text{F}$) for 30 minutes.
5. Determine and record the mass of the coated specimen to the nearest 0.1 g. Designate this mass as “D”.
6. Fill the water bath to overflow level with water at $25 \pm 1^{\circ}\text{C}$ ($77 \pm 1.8^{\circ}\text{F}$).
7. Immerse the specimen in water at $25 \pm 1^{\circ}\text{C}$ ($77 \pm 1.8^{\circ}\text{F}$) for 4 ± 1 minutes.
8. Determine and record the submerged weight to the nearest 0.1 g. Designate this submerged weight as “E”.
9. Determine the specific gravity of paraffin or parafilm at $25 \pm 1^{\circ}\text{C}$ ($77 \pm 1.8^{\circ}\text{F}$) from the manufacturer’s literature or other suitable source. Designate this specific gravity as “F”.

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**Calculations - Method D Suspension
(Coated Specimens/AASHTO T 275)**

$$G_{mb} = \frac{A}{D - E - \left[\frac{D - A}{F} \right]}$$

where:

- G_{mb} = Bulk Specific Gravity
- A = Mass of dry specimen in air, g
- D = Mass of specimen with paraffin coating in air, g
- E = Weight of specimen with paraffin coating in water, g
- F = Specific gravity of paraffin or parafilm at $25 \pm 1^{\circ}\text{C}$ ($77 \pm 1.8^{\circ}\text{F}$)

Apparatus – Method E Volumeter (Coated Specimens/AASHTO T 275)

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- Balance or scale: 5 kg capacity, readable to 0.1 g and conforming to AASHTO M 231.
- Water bath: thermostatically controlled to $25 \pm 0.5^{\circ}\text{C}$ ($77 \pm 0.9^{\circ}\text{F}$).
- Thermometer: Range of 19 to 27°C (66 to 80°F), and graduated in 0.1°C (0.2°F) subdivisions.
- Volumeter: Calibrated to 1200 mL or appropriate capacity for test sample and having a tapered lid with a capillary bore.
- Oven: Capable of maintaining a temperature of $110 \pm 5^{\circ}\text{C}$ ($230 \pm 9^{\circ}\text{F}$) for drying the specimens to a constant mass.
- Pan: Pan or other suitable container of known mass, large enough to hold a sample for drying in oven.
- Towel: Damp towel used for surface drying specimens.

Procedure - Method E Volumeter (Coated Specimens/AASHTO T 275)

1. Dry the specimen to constant mass. See note 1.
- 35 2. Cool the specimen in air at $25 \pm 5^{\circ}\text{C}$ ($77 \pm 9^{\circ}\text{F}$), and determine and record the dry mass to the nearest 0.1 g. Designate this mass as "A".
3. Coat the specimen all surfaces with paraffin, or parafilm coating, sufficiently thick to seal all voids.
4. Allow coating to cool in air at $25 \pm 5^{\circ}\text{C}$ ($77 \pm 9^{\circ}\text{F}$) for 30 minutes.
- 36 5. Determine and record the mass of the coated specimen to the nearest 0.1g. Designate this mass as "C".
6. Fill the volumeter with distilled water at $25 \pm 1^{\circ}\text{C}$ ($77 \pm 1.8^{\circ}\text{F}$) and place the coated specimen in the volumeter.
- 37 7. Bring the temperature of the water to $25 \pm 1^{\circ}\text{C}$ ($77 \pm 1.8^{\circ}\text{F}$), and cover the volumeter making sure some water escapes through the capillary bore of the tapered lid.
- 38 8. Wipe the volumeter dry.
9. Determine and record the mass of the voltmeter and specimen to the nearest 0.1 g. Designate this mass as "E".
10. Determine the specific gravity of paraffin or parafilm at $25 \pm 1^{\circ}\text{C}$ ($77 \pm 1.8^{\circ}\text{F}$) from the manufacturer's literature or other suitable source. Designate this specific gravity as "F".

Calculations - Method E Volumeter (Coated Specimens/AASHTO T 275)

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$$G_{mb} = \frac{A}{D - \left[E - C + \left(\frac{C - A}{F} \right) \right]}$$

where:

G_{mb} = Bulk Specific Gravity

A = Mass of dry specimen in air, g

C = Mass of specimen with paraffin coating in air, g

D = Mass of volumeter filled water at 25 ±1°C (77 ±1.8°F), g

E = Mass of volumeter filled with specimen with paraffin coating and water 25 ±1°C (77 ±1.8°F), g

F = Specific gravity of paraffin or parafilm at 25 ±1°C (77 ±1.8°F)

Report

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Results shall be reported on standard forms approved for use by the agency. Report the G_{mb} to 3 decimal places and absorption to 2 decimal places. Report the method performed.

Tips!

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- Use method approved by agency.
- Check for open or interconnecting voids or absorption over 2.0 percent. Use Method D, if appropriate.
- Check temperature of water in water bath.

REVIEW QUESTIONS

1. For how long must samples be submerged prior to determining immersed weight for Method A?
2. In determining SSD mass of a specimen, how must the sample be dried?
3. At what temperature and for how long should cored samples be dried?
4. How do methods A and B differ?

PERFORMANCE EXAM CHECKLIST

BULK SPECIFIC GRAVITY OF COMPACTED HOT MIX ASPHALT USING SATURATED SURFACE-DRY SPECIMENS FOP FOR AASHTO T 166

BULK SPECIFIC GRAVITY OF COMPACTED BITUMINOUS MIXTURES USING PARAFFIN-COATED SPECIMENS FOP FOR AASHTO T 275

Participant Name _____ Exam Date _____

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

Procedure Element	Trial 1	Trial 2
--------------------------	----------------	----------------

Method A:

- | | | |
|---------------------------------------------------------------------------------------------------------------------------------------|-------|-------|
| 1. Mass of dry sample in air determined. | | |
| a. Dried overnight at $52 \pm 3^{\circ}\text{C}$ ($125 \pm 5^{\circ}\text{F}$) and at successive 2-hour intervals to constant mass? | _____ | _____ |
| b. Cooled to room temperature, $25 \pm 5^{\circ}\text{C}$ ($77 \pm 9^{\circ}\text{F}$)? | _____ | _____ |
| c. Dry mass determined to 0.1g? | _____ | _____ |
| 2. Water at the overflow? | _____ | _____ |
| 3. Immersed weight determined. | | |
| a. Water at $25 \pm 1^{\circ}\text{C}$ ($77 \pm 1.8^{\circ}\text{F}$)? | _____ | _____ |
| b. Immersed at 4 ± 1 minutes? | _____ | _____ |
| c. Immersed weight determined to 0.1g | _____ | _____ |
| 4. Sample rapidly surface dried with damp cloth? | _____ | _____ |
| 5. Saturated surface-dry (SSD) mass determined to 0.1g? | _____ | _____ |
| 6. G_{mb} calculated to 0.001? | _____ | _____ |
| 7. Calculate percent water absorbed determined to be less than 2.0 percent? | _____ | _____ |

Method B:

- | | | |
|-------------------------------------------------------------------------------------------------|-------|-------|
| 1. Specimen dried, cooled, and mass determined as in Method A? | _____ | _____ |
| 2. Saturated surface-dry (SSD) mass determined to 0.1g. | | |
| a. Immersed at least 10 minutes at $25 \pm 1^{\circ}\text{C}$ ($77 \pm 1.8^{\circ}\text{F}$)? | _____ | _____ |
| b. Sample rapidly dried with damp towel? | _____ | _____ |
| c. Specimen mass determined to 0.1g? | _____ | _____ |
| d. Any water that seeps from specimen included in mass? | _____ | _____ |

OVER

Procedure Element	Trial 1	Trial 2
3. Mass of volumeter filled with distilled water at $25 \pm 1^{\circ}\text{C}$ ($77 \pm 1.8^{\circ}\text{F}$) determined?	_____	_____
4. SSD specimen placed into volumeter and let stand for 1 minute?	_____	_____
5. Temperature of water brought to $25 \pm 1^{\circ}\text{C}$ ($77 \pm 1.8^{\circ}\text{F}$) and volumeter covered, allowing some water to escape through the capillary bore of the tapered lid?	_____	_____
6. Volumeter wiped dry, and mass of volumeter and contents determined?	_____	_____
7. G_{mb} calculated to 0.001?	_____	_____
8. Calculate percent water absorbed determined to be less than 2.0 percent?	_____	_____
Method C/A:		
1. Immersed weight determined.		
a. Water at $25 \pm 1^{\circ}\text{C}$ ($77 \pm 1.8^{\circ}\text{F}$)?	_____	_____
b. Immersed at 4 ± 1 minutes?	_____	_____
c. Immersed weight determined to 0.1g?	_____	_____
2. Sample rapidly surface dried with damp cloth?	_____	_____
3. Saturated surface-dry mass determined to 0.1g?	_____	_____
4. Dry mass determined by:		
a. Heating in oven at a minimum of 105°C (221°F)?	_____	_____
b. Breaking down to 6.4 mm (1/4 in.) particles?	_____	_____
c. Drying in oven to constant mass (change less than 0.05 percent in 2-hours of additional drying)?	_____	_____
d. Cooling to temperature of $25 \pm 5^{\circ}\text{C}$ ($77 \pm 9^{\circ}\text{F}$) and mass determined to 0.1g?	_____	_____
5. G_{mb} calculated to 0.001?	_____	_____
6. Calculated percent water absorbed determined to be less than 2.0 percent?	_____	_____
Method C/B:		
1. Saturated surface-dry (SSD) mass determined to 0.1g.		
a. Immersed at least 10 minutes at $25 \pm 1^{\circ}\text{C}$ ($77 \pm 1.8^{\circ}\text{F}$)?	_____	_____
b. Sample rapidly dried with damp towel?	_____	_____
c. Specimen mass determined to 0.1g?	_____	_____
d. Any water that seeps from specimen included in mass?	_____	_____
2. Mass of volumeter filled with distilled water at $25 \pm 1^{\circ}\text{C}$ ($77 \pm 1.8^{\circ}\text{F}$) determined to 0.1g?	_____	_____

OVER

Procedure Element	Trial 1	Trial 2
3. SSD specimen placed into volumeter and let stand for 1 minute?	_____	_____
4. Temperature of water brought to $25 \pm 1^{\circ}\text{C}$ ($77 \pm 1.8^{\circ}\text{F}$) and volumeter covered, allowing some water to escape through the capillary bore of the tapered lid?	_____	_____
5. Volumeter wiped dry, and mass of volumeter and contents determined to 0.1g?	_____	_____
6. Dry mass determined by:		
a. Warming in oven at a minimum of 105°C (221°F)?	_____	_____
b. Breaking down to 6.4 mm ($\frac{1}{4}$ in.) particles?	_____	_____
c. Drying in oven to constant mass (change less than 0.05 percent in 2-hours of additional drying)?	_____	_____
d. Cooling to temperature of $25 \pm 5^{\circ}\text{C}$ ($77 \pm 9^{\circ}\text{F}$) and mass determined to 0.1g?	_____	_____
7. G_{mb} calculated to 0.001?	_____	_____
8. Calculated percent water absorbed determined to be less than 2.0 percent?	_____	_____
Method D:		
1. Mass of dry sample in air determined to 0.1g.		
a. Dried overnight at $52 \pm 3^{\circ}\text{C}$ ($125 \pm 5^{\circ}\text{F}$) and at successive 2-hour intervals to constant mass?	_____	_____
b. Cooled to room temperature, $25 \pm 5^{\circ}\text{C}$ ($77 \pm 9^{\circ}\text{F}$)?	_____	_____
c. Mass of dry sample determined to 0.1g?	_____	_____
2. Specimen sufficiently coated to seal all voids and cooled for 30 minutes?	_____	_____
3. Mass of coated specimen determined to 0.1g?	_____	_____
4. Immersed weight determined to 0.1g.		
a. Water at $25 \pm 1^{\circ}\text{C}$ ($77 \pm 1.8^{\circ}\text{F}$)?	_____	_____
b. Immersed at 4 ± 1 minutes?	_____	_____
c. Immersed weight determined 0.1g?	_____	_____
5. G_{mb} of coating determined?	_____	_____
6. G_{mb} calculated to 0.001?	_____	_____
Method E:		
1. Mass of dry sample in air determined to 0.1g?		
a. Dried overnight at $52 \pm 3^{\circ}\text{C}$ ($125 \pm 5^{\circ}\text{F}$) and at successive 2-hour intervals to constant mass (or by other means, if allowed)?	_____	_____
b. Cooled to room temperature, $25 \pm 5^{\circ}\text{C}$ ($77 \pm 9^{\circ}\text{F}$)?	_____	_____
c. Mass of dry sample determined to 0.1g?	_____	_____

OVER

Procedure Element	Trial 1	Trial 2
2. Specimen sufficiently coated to seal all voids and cooled for 30 minutes?	_____	_____
3. Mass of coated specimen determined to 0.1g?	_____	_____
4. Mass of volumeter filled with distilled water at $25 \pm 1^{\circ}\text{C}$ ($77 \pm 1.8^{\circ}\text{F}$) determined to 0.1g?	_____	_____
5. SSD specimen placed into volumeter?	_____	_____
6. Temperature of water brought to $25 \pm 1^{\circ}\text{C}$ ($77 \pm 1.8^{\circ}\text{F}$) and volumeter covered, allowing some water to escape through the capillary bore of the tapered lid and let stand for 1 minute?	_____	_____
7. Volumeter wiped dry, and mass of volumeter and contents determined to 0.1g?	_____	_____
8. G_{mb} calculated to 0.001?	_____	_____

Comments: First attempt: Pass ☐ Fail ☐ Second attempt: Pass ☐ Fail ☐

Examiner Signature _____ WAQTC #: _____